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SCN2261 Physics 20
Module 4 Assignment

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Physics 20

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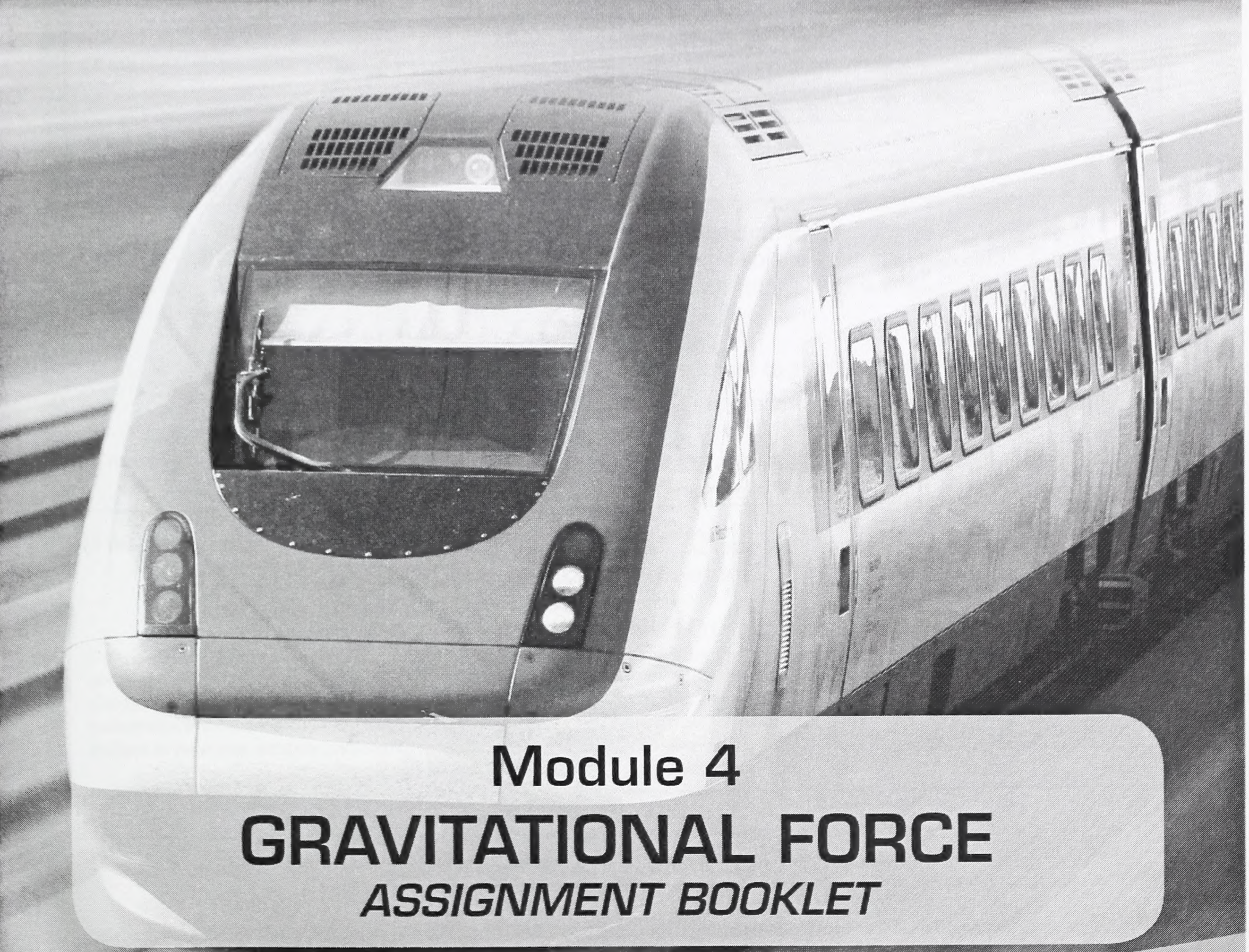

Module 4

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Summary

	Total Possible Marks	Your Mark
Lesson 1 Assignment	22	
Lesson 2 Assignment	18	
Lesson 3 Assignment	19	

Teacher's Comments

Physics 20
Module 4: Gravitational Force
Assignment Booklet
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MODULE 4: LESSON 1 ASSIGNMENT

This Module 4: Lesson 1 Assignment is worth 22 marks. The value of each assignment and each question is stated in the left margin.

(22 marks) Lesson 1 Assignment: Acceleration Due to Gravity

TR 1. On the simulator, click the “Vector” button (↗), and then click anywhere in the display to see the gravitational field vector (*g*). Click and hold to drag it around Earth. You will notice two general characteristics of the gravitational field.

(1 mark) a. As you move closer to Earth, the gravitational field becomes _____________, as illustrated by the length of the vector.

(1 mark) b. The gravitational field is always directed ____________ the centre of Earth.

(2 marks) c. The largest value for *g* (acceleration due to gravity), as displayed in the data table, is __________ and occurs at the ___________ of Earth. (**Note:** The units for *g* (N/kg), as displayed in the applet, are identical to the more familiar unit for acceleration (m/s^2). You will learn more about this later in the lesson.)

Note that the “E” in the data table refers to the “Exponent for a power of 10.” For example, 8.15E6 m is written in conventional notation as 8.15×10^6 m.

(6 marks) **TR 2.** Using the simulator, experimentally determine how the gravitational field strength (*g*) varies with the distance from Earth (*d*).

(3 marks) a. Click on a point near Earth's surface. For this point, record the following values in the table using conventional notation:

- the distance (*d*), measured from the centre of Earth
- the gravitational field strength (*g*) at this point

Click and drag the field vector farther away from the surface. Record the new distance and gravitational field strength (g) at this point. Complete the data table that follows.

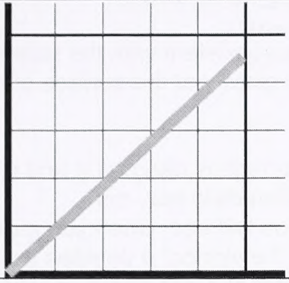
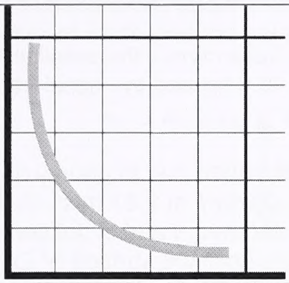
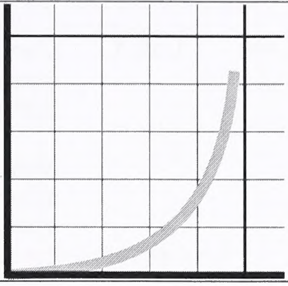
Distance (*d*) m	Gravitational Field Strength (*g*) N/kg

(3 marks)

b. Choose an appropriate scale and plot the data on the graph provided. The manipulated variable (d) is on the *x*-axis, and the responding variable (*g*) is on the *y*-axis.

Gravitational Field Strength vs. Distance

(2 marks) **TR 3.** Which mathematical relationship best describes your graph of gravitational field strength versus distance? State the relationship using *g* for gravitational field strength and *d* for distance from source.

A. relationship: $y \propto x$	B. relationship: $y \propto \frac{1}{x^2}$	C. relationship: $y \propto x^2$
		

(10 marks) **TR 4.** Complete “4-2 QuickLab: Relating Mass and Weight” on page 198 in your textbook. Obtain the needed materials from your teacher. Be sure to zero the spring scale in the upright position before you start to take measurements. Let mass (in kg) be the manipulated variable, and plot it on the horizontal axis of your graph.

MODULE 4: LESSON 2 ASSIGNMENT

This Module 4: Lesson 2 Assignment is worth 18 marks. The value of each assignment and each question is stated in the left margin.

(18 marks) Lesson 2 Assignment: Newton's Law of Universal Gravitation

(1 mark) **LAB 1.** Using $W = mg$, determine if the satellite's weight is consistent with the satellite's mass given as 40.0 kg and the acceleration due to gravity at the surface of the Earth (9.81 m/s^2).

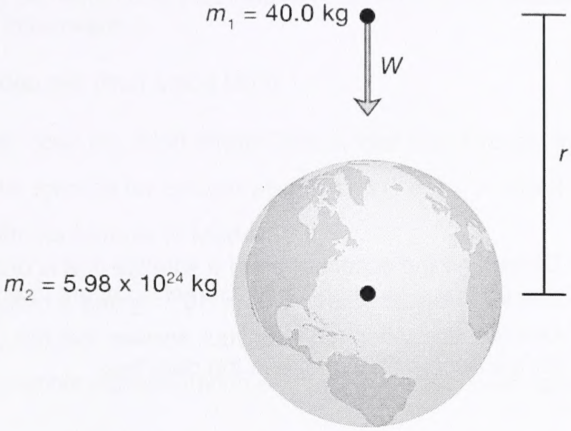
Note: The acceleration due to gravity on Earth's surface is denoted *g* and is approximately constant at 9.81 m/s^2. In the simulation data box, the acceleration is denoted *a* and is not constant, as you will see, when you move the satellite away from the surface of Earth. Thus, the symbol *g* denotes a constant that applies at Earth's surface, and the symbol *a* denotes a variable (less than 9.81 m/s^2) for the acceleration due to gravity at any arbitrary point away from Earth.

LAB 2. What is the satellite's weight at a point one Earth radius above Earth's surface? On the simulation, position the satellite at $x = 0$ km and $y = 6378$ km. Enter these values in the position data entry fields and then press "Enter." To view the satellite's new position, zoom out using the scale selections. Again, the weight is displayed at the bottom of the data box.

(1 mark) a. What is the weight of the satellite at one Earth radius from the surface?

(1 mark) b. If the satellite's weight changed but its mass remained constant, what variable has changed according to $W = ma$?

(2 marks) **LAB 3.** Away from the surface of Earth, $W = mg$ is no longer valid. You would need to use $W = ma$, assuming that you knew what the acceleration was at the satellite's position. (Remember that g is a constant 9.81 m/s^2 and is only valid at Earth's surface.) Newton's law of universal gravitation is most useful away from the surface of Earth. Use this equation to determine if the satellite's weight in LAB 2 is consistent with the satellite's mass (40.0 kg) and the distance between the centre of Earth and the satellite. See the accompanying illustration.



(3 marks) **TR 1.** Determine the gravitational force of attraction between a small cargo ship (5.00×10^4 kg) and a supertanker (1.50×10^6 kg) that is 500 m away. Compare your answer to the force of attraction between Earth and the Moon. Why are gravitational forces between masses on Earth so small?

(2 marks) **TR 2.** Determine the acceleration on the surface of the Moon if it has a radius of 1.74×10^6 m and a mass of 7.35×10^{22} kg. Explain how this would affect the walking pattern of a human being.

(2 marks) **TR 3.** Determine the acceleration of a satellite that is orbiting Earth at an altitude of 600 km. Use a mass of 5.98×10^{24} kg and a radius of 6.378×10^6 m for Earth. Use the simulation to verify your answer. Set the *y* position to 600 km, and look for the acceleration value in the data box.

(2 marks) **TR 4.** Complete question 1 of the “Practice Problems” on page 220 of the textbook.

(6 marks)

Reflect and Connect

Is the Moon falling, just like an apple from a tree? Newton's law of universal gravitation would have you believe just that, yet the motion of the Moon appears to contradict the definition of acceleration for a falling apple. Both the apple and the Moon are under the influence of the same gravitational field, yet they appear to move very differently. View the following two video clips to compare and contrast the motion of a falling apple with the motion of the Moon.

(**Note:** You may be required to login with a username and a password. Contact your teacher for this information.)

View the first video clip titled Moon Orbit 1.

View the second video clip titled Moon Orbit 2. Half way through the clip, it's assumed that you know the formula for circular acceleration, $a = \frac{v^2}{r}$. Don't be confused by this; you will work with the formula in Module 5.

Choose from one of the following activities to identify, and explain the contradiction you have witnessed.

- Create a graphic representation of the contradiction with labels.
- Create a model of what is happening.
- Explain the contradiction through mathematics.
- Create a written scenario identifying what would need to change for the Moon to fall into Earth and the consequences if this were to happen.

MODULE 4: LESSON 3 ASSIGNMENT

This Module 4: Lesson 3 Assignment is worth 19 marks. The value of each assignment and each question is stated in the left margin.

(19 marks)

Lesson 3 Assignment: Universal Gravitational Field Theory and the Density of Earth

(2 marks) **TR 1.** Explain how Cavendish was able to determine the force of attraction in his experimental apparatus.

(2 marks) **TR 2.** The mass of each lead ball in Cavendish's experiment was 195 kg. Given the value of *G*, what would be the expected force of attraction between two of these balls if their centres were separated by 1.0400 m?

(3 marks) **TR 3.** Given the value for the universal gravitational constant, the average value for the acceleration due to gravity at the surface of Earth and the radius of Earth, determine Earth's mass. (Earth's radius can be found on the physics data sheet in the Constants section along with other useful information.)

Constants

Acceleration Due to Gravity Near Earth	$\left\|\vec{a}_g\right\| = 9.81\ \text{m/s}^2$
Gravitational Constant	$G = 6.67 \times 10^{-11}\ \text{N}\cdot\text{m}^2/\text{kg}^2$
Radius of Earth	$r_e = 6.37 \times 10^{6}\ \text{m}$
Mass of Earth	$M_e = 5.98 \times 10^{24}\ \text{kg}$
Elementary Charge	$e = 1.60 \times 10^{-19}\ \text{C}$

Coulomb's Law Constant	$k = 8.99 \times 10^9$ N•m^2/C^2
Electron Volt	1 eV $= 1.60 \times 10^{-19}$ J
Index of Refraction of Air	$n = 1.00$
Speed of Light in Vacuum	$c = 3.00 \times 10^8$ m/s
Planck's Constant	$h = 6.63 \times 10^{-34}$ J•s
	$h = 4.14 \times 10^{-15}$ eV•s
Atomic Mass Unit	$u = 1.66 \times 10^{-27}$ kg

(4 marks) **TR 4.** **Density** is a measure of the mass per unit of volume for a material. Mathematically, this can be expressed in units of kg/m^3. Given that the equation for the volume of sphere is based on radius, determine the density of Earth and compare it to that of water (998 kg/m^3 at 20º C). Explain how this helps people understand Earth's interior.

$$\text{volume} = \frac{4}{3}\pi r^3$$

$$\text{density} = \frac{\text{mass}}{\text{volume}}$$

(8 marks)

Reflect and Connect

In a couple of paragraphs, explain how NASA engineers applied Cavendish's work and Newton's law of universal gravitation when the following tasks were completed:

- The spacecraft had to approach Mars at a very high rate of speed while being pulled in by an increasingly strong gravitational field. Scientists needed to slow the spacecraft down considerably before it reached the atmosphere and slow the spacecraft down some more again before it reached the surface.
- The rover had to survive a direct impact when it reached the surface.
- The rover's locomotion system had to support its weight on Mars, on a relatively unknown terrain with hills and rocks.
- The rover's locomotion system had to operate on minimal power.

Once you have completed all of the questions, submit your work to your teacher.

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